

When the fork vibrates, this image is drawn out into a band of light. When the mirror commences to revolve, this band breaks up into a number of moving images of the mirror; and when, finally, the mirror makes as many turns as the fork makes vibrations, these images are reduced to one which is stationary. This is also the case when the number of turns is a sub-multiple. When it is a multiple, or a simple ratio, the only difference is that there will be more than one image.

Hence, to make the mirror execute a given number of turns, all that is necessary is to pull the cord attached to the valve, to the right or left, till the images of the revolving mirror come to rest.

The electric fork made about 128 vibrations per second. No dependence was placed upon this rate, however, but at each set of observations it is compared with a standard U_3 fork, the temperature being noted at the same time. In making the comparison the beats were counted for 60 seconds.

It is interesting to note that the electric fork, as long as it remained untouched and at the same temperature, did not change its rate more than 0.01 or 0.02 vibration per second.

Fig. 6 represents the table at which the observer sits. The light from the heliostat passes through the slit at *s*, goes to the revolving mirror, etc., and on its return forms an image of the slit at *D*, which is observed through the eyepiece. *E* represents the electric fork, bearing the steel mirror, *M*; *K*, the standard fork on its resonator.

The lens was made by Alvan Clark. It was 8 inches in diameter, focal length 150 feet, not achromatic. It was mounted in a wooden frame, placed on a support moving on a slide about 16 feet long, placed about 80 feet from the building. As the diameter of the lens was so small in comparison with its focal length, its want of achromatism was inappreciable. For the same reason the effect of "parallax" was too small to be noticed.

The stationary mirror was one of those used in taking photographs of the transit of Venus. It was about 7 inches in diameter, mounted in a brass frame capable of adjustment in a vertical and a horizontal plane by screw motion. Being prismatic, it had to be silvered on the front surface. To facilitate adjustment, a small telescope furnished with cross hairs was attached to the mirror by a universal joint. The heavy frame was mounted on a brick pier, and the whole surrounded by a wooden case, to protect it from the sun.

The adjustment was effected as follows:—

A theodolite was placed at about 100 feet in front of the mirror, and the latter was moved about, till the observer at the theodolite saw the image of his glass reflected in the centre of the mirror. Then the telescope attached to the mirror was pointed at a mark on a piece of cardboard attached to the theodolite. Thus, the axis of the telescope was placed at right angles to the surface of the mirror. The theodolite was then moved to 1,000 feet, and, if found necessary, the adjustment repeated. Then the mirror was moved till its telescope pointed at the hole in the shutter of the building. The adjustment was completed by moving the mirror by signals, till the observer, looking through the hole in the shutter through a good spyglass, saw the image of the glass reflected centrally in the mirror.

Notwithstanding the wooden case about the pier the mirror would change its position between morning and evening, so that the last adjustment had to be repeated before every series of experiments.

(To be continued.)

ON THE MOUNTAINS OF THE NORTHERN AND WESTERN FRONTIER OF INDIA¹

THERE are certain moot questions relating to the mountains of the north-west frontier of India upon which it appears desirable to elicit the opinion of geographers. On this occasion I propose to discuss the western limits of the Himalaya; the northern and southern limits of the Hindu Kush; the parallelism and lateral communications of the ranges between the Hindu Kush and the Aralo-Caspian plain and of other parts of the north-west frontier; and the limits of the Iranian group of highlands, at its junction with the Tibeto-Himalayan and Pamir groups. Finally the proper route of a railway to India between Mesopotamia and the Indus is indicated along a remarkable line of elevated valleys parallel to the coast.

¹ Paper read at the Sheffield meeting of the British Association by Trelawney W. Saunders.

The Himalaya ranges form a part of the great girdle of mountains which continuously encircle the central portion of the Asiatic Continent, and include the Chinese colonial dependencies of Ili, Mongolia, Kokonor, and Tibet.

This vast mountain girdle is naturally grouped into four parts corresponding with the outlets of its exterior drainage according to their connection with the Arctic, Pacific, and Indian Oceans, and the Aralo-Caspian Seas respectively. These four divisions of the great mountain girdle have been named from their chief features, (1) the Tibeto-Himalayan, (2) the Yunling, (3) the Altaic, and (4) the Pamir systems. The interlacing or overlapping of these systems at their junctions is not always easy to make out, and presents occasional difficulties like other systems of classification, no matter what the subject may be.

The question of the western termination of the Himalaya relates to two divisions of the great girdle, namely, The Tibeto-Himalayan and the Pamir, to which must be added another group lying outside those two, but impinging on them at its north-east corner. This group is formed by the Iranian highlands, a compact quadrilateral mass bounded by the lowlands of the Indus, the Arabian Sea and the Persian Gulf, the lowland of the Tigris and Euphrates, and the Aralo-Caspian plain. The only questions which can well arise with regard to the boundaries of the Iranian mountain system, relate to its north-west and north-east angles, where it unites with the Tauric system on the one hand and the Himalaya and Pamir on the other. It is with the latter only that we propose to deal now.

My Tibeto-Himalayan system was introduced in 1870 in "A Sketch of the Mountains and River Basins of India in two Maps, with Explanatory Memoirs." It was further developed in the *Geographical Magazine*, for July, 1877; and I am indebted to the distinguished chairman of this section for an appreciative account of it in two editions of his "Memoirs of the Indian Surveys in 1871 and 1877." It resolves the leading features of the vast mass of which it treats into four great chains with their outer slopes and intermediate valleys or plateaus. I am obliged to allude briefly to this bygone work, for the purpose of forming a logical basis for the argument which follows.

The northern and southern Himalaya are two of these great chains. The Karakorum-Gangri and the Kuenlun are the other two. The Southern Himalaya rises from the great plain of India, and its culminating summit is distinguished by an extraordinary chain of snowy peaks throughout the whole extent which is claimed for it. The catenary and close succession of these snowy peaks cannot be denied, for they have been fixed in position and altitude by the indubitable observations of the great Trigonometrical Survey of India. Nor can the existence be disputed of the line of valleys which forms the northern base of this snowy range and distinctly separates it from the Northern Himalaya.

Yet an antiquated theory conceived before the existence of this snowy range was demonstrable, is still held to be possibly tenable by the authors of the recently published manual of the Geology of India, although they do not condescend to any reason for their conclusion.

Now this is not merely a matter of dispute between geologists and geographers, but it is one of the greatest practical importance with reference particularly to the potent question of lateral communications about which much has been said lately in reference to the Iranian system in Afghanistan. In the successive valleys following one after the other in the same line, each of which I have specifically named in the *Geographical Magazine*, there is indisputable evidence of the separation of the two ranges, and of that lateral communication which is an ordinary feature of mountain systems, rather than otherwise.

The Northern Himalaya has its southern base in these valleys, while its northern base is found in the extended trough along which flows the upper courses of the great rivers Indus, Sutlej, and Sanpu.

It is usually said that the Himalaya extends up to the gorge of the Indus on the west and to the gorge of the Sanpu on the east, and this is the extent assigned to the Himalaya by the authors of the "Manual of the Geology of India." But this restriction falls short of the limits which we have already assigned to the Tibeto-Himalayan system, on the basis of the natural oceanic watersheds. It also falls short of the extension attributed to the Himalaya on the west by observers and geographers of celebrity; and we shall endeavour to prove that it falls short, on the west at least, of the plain and simple application of the same conditions as those on which the Himalaya is allowed to extend up to the gorge of the Indus.

The valley of the Upper Indus running from south-east to north west, at the northern base of the Northern Himalaya, and between the Northern Himalaya and the Karakorum Mountains, is carried forward in the same direction by the valley of the Gilgit river up to Yassin, and thence over a relatively low water-parting into the upper valley of the Kunar river. Near the confluence of the Indus with the Gilgit, the Indus makes a rectangular bend on entering the gorge through which it intersects both ranges of the Himalaya to enter the plain of Peshawur. But the range of the Northern Himalaya which, it is allowed, dominates the left bank of the Indus as far as the gorge, does not cease there, but is continued across the Indus in the same direction as before, and proceeding westward forms the southern barrier of the Gilgit, Yassin, and Chitral valleys, until it meets the Hindu Kush on the west of the Kunar river. The separation of the Hindu Kush from the Himalaya will be discussed further on. The valleys of Gilgit, Yassin and Chitral, in which the base of the Northern Himalaya is found, are indeed a prolongation of the great trough which forms its northern base throughout. At the extremity of the Himalaya the Kunar river drives a passage through a gorge which remains unexplored, although it is probably not less accessible than the gorge of the Indus with which we have only recently been made acquainted.

Having now traced the Northern Himalaya up to the Hindu Kush, the continuation of the Southern Himalaya west of the gorge of the Indus remains to be made out. It is defined by a series of peaks fixed by the Trigonometrical Surveyors in a line from that gorge up to the southern end of the Kunar gorge. Beyond the Kunar, the line of peaks bulges southward and bends again northward following the base formed by the Kunar, the Kabul and the Panjshir valleys, till it meets the Hindu Kush. Like the rest of the peaks of the Southern Himalaya, the peaks west of the Indus form the culminating summits of the southern slope which ascends in unbroken continuity along the whole extent of the Indian lowland, from the eastern extremity of the valley of Assam to the plain of Peshawur, and the line of the Kabul river. Lieut. Wood, the explorer of the Oxus, who as surveyor accompanied Sir Alexander Burnes' famous mission to Kabul, remarks that "the Himalaya, as is well known, bounds Hindustan on the north, and after crossing the river Indus, extends westward to the valley of Panjshir." The Trigonometrical surveyors have since defined the exact position of the great peaks which mark the culminating summit of the range along its whole extent. At the present time, we have still to await the exploration of the high ground between the northern and southern ranges west of the Indus. There is little doubt that it will be found to correspond with the rest of the interval between the ranges throughout their extended course.

We may now turn to the Hindu Kush. The ends of the axis of the Hindu Kush are well defined as that axis is the water-parting between the basins of the Indus and the Oxus. Its southern base is to be sought in the same line of watercourses which define the northern base of the Northern Himalaya with the addition westward of the Ghorband valley. The known parts of this line include the Ghorband and Panjshir valleys, and the Upper Kunar in Chitral. It remains for future exploration in Kafiristan to trace out a line of lateral valleys serving to connect the Panjshir with the Upper Kunar, in order to complete the line of contact and division between the Hindu Kush and the Northern Himalaya.

The northern base of the Hindu Kush may be traced from Bamian along the Surkhhab to its junction with the Anderab valley, from the head of which, I have little doubt, a line of lateral valleys will be found connecting Anderab with Kuran, Zebak, the Panja, and the Sarhad-wakhan or southernmost head of the Oxus.

The division between the Hindu Kush and the Himalaya is, so far as it goes, likewise the division between the Tibeto-Himalayan system and that of the Pamir. To complete the division of the latter systems we must find a line of watercourses from the Kunar river up to the Tagh Dumbash Mountain, which marks the common termination of the Karakorum and the Hindu Kush; and from the Tagh Dumbash Mountain the dividing line of the two systems must be carried down to the plain of Yarkand by an affluent of the Yarkand river.

The Pamir group of mountains has the southern base of the Hindu Kush for a part of its southern limit. Its western base is in the plain of Gobi between the Yarkand and Kashgar rivers. Its northern base is in the plain of Kokand or Ferghana, watered by the Syr Daria or Jaxartes of the ancients. The

western base strikes southward along the foot of the mountains; crosses the Zarafshan river and passes Bokhara; after which the group bends round to the eastward and finds its southern base along the right bank of the Oxus, up to its outlet from the mountains; then it follows the mountains crossed by the Lataband Pass, to the Akserai or Surkhhab river, which it ascends to Bamian and Ghorband, where the continuation of the southern base of the Pamir group is found in the southern base of the Hindu Kush, as already mentioned.

We have heretofore defined the indisputable limits of the great quadrilateral Iranian group, and while the recollection of the limit of the Pamir along the course of the Surkhhab or Akserai to Bamian and Ghorband, is fresh upon us, we will at once point to the same line as defining the separation and the contact of the Iranian and Pamir groups. From Ghorband by the line of the Kabul river to the Indus, is also traced, the separation and the contact of the Iranian with the Himalayan group. We cannot see that a more distinct or better limitation can be suggested for these important items of geographical nomenclature.

The principal ranges in the Pamir group are now fairly made out by British and Russian observers. The most easterly range is that of the Western Kuenlun, which rises in the plain of the Gobi above the cities of Yarkand and Kashgar, and culminates in snowy peaks, of which Togarmah is 25,500 feet in height above the sea, and Tash-balik is 22,500 feet. Westward of the Kuenlun range is the water-parting between the basins of Lake Lob and of the Oxus, a range which is in continuation with the Karakorum and Hindu Kush, and the meeting of the three is at Tagh Dumbash. This range was long since pointed out by that grand geographer Baron Humboldt, and was identified by him with the Bolor of Oriental writers. An attempt has been made by a mistaken Russian geologist and some of his followers, and also by a critic distinguished for another reason, to do away with this well established and distinctive name; but such a feature parting two famous river basins and connecting other great ranges cannot go unnamed; and we contend that the name rendered classical by the labours of Alexander Humboldt, ought to be maintained. This Bolor range is separated from the Kuenlun by a series of valleys with streams that descend to the Gobi, including the Kizilyart Plain in the northern part, while in the southern part the repetition of the name Tagharmah is probably connected with the ancient Toghari, or Tochari. The Bolor range also forms the eastern limit of the Pamir or Roof of the World, a lofty plateau rich in summer pastures, drained by the Oxus and its affluents, and bounded on the west by another great range named Khoja Mohammed.

If we compare this part of the Pamir system with the western Himalaya, a certain similarity will be observed. Thus the Upper Oxus between the Khoja Mohammed and Bolor ranges, flows at an altitude similar to that of the Upper Indus, between the Northern Himalaya and the Karakorum ranges, or about 10,000 feet. West of the Khoja Mohammed range, is the range crossed by the Lataband pass, the latter separating the lowland of Kunduz from the elevated valley of Lower Badakshan, just as the southern Himalaya separates the elevated valley of Kashmir, from the lowland of the Punjab.

Lieut. Wood represented the Khoja Mohammed range as extending from the great bend of the Oxus to the Kokcha or river of Badakshan, and beyond that river in a south-westerly direction, that is, nearly parallel with the Hindu Kush. We shall consider its further extension presently. Similarly the Lataband range must be regarded as extending all along the Aralo Caspian plain from Kunduz to the Caspian Sea, and along the south of that sea to the Armenian plateau. Like the southern Himalaya it has its outer base in the great plain, but the inner base, has so far only been made out at intervals, and is an object that well deserves observation with reference to the existence of natural facilities for lateral communication along the side of the highland.

In pursuing this interesting subject we have to point to two well determined parallel lines already set out forming, respectively the great waterparting and the base in the plains. The water-parting in question is formed in continuation of Karakorum westward, (1) by Hindu² Kush, between the Oxus and Indus basins; (2) by Koh-i-Baba between the Oxus and Helmund basins; (3) by Siah Koh between the Murghab and Helmund. We will not pursue the culminating line further at present. A succession or chain of lateral valleys follows we believe both sides of this summit. On the north side we follow the Upper

Oxus as far as it flows parallel with the Hindu Kush; then cross over the pass of Ishkashm to the Upper Kokcha from which in all probability the Anderab valley is accessible, and also Bamian. From Bamian Capt. Conolly passed to the upper waters of the river of Balkh and thence into the valley of Hari Rud, which expands westward to the meridian of Herat.

Between the meridian of Herat and Kabul, at least three lines of lateral communication are partially delineated. These are the parallel valleys of the Hari Rud, of the Murghab, and of the route traversed by Vambery, and the Russian officer Grodekov. Indeed it can be still further demonstrated that practical lateral communication exists throughout the whole length of the Iranian and Himalayan systems, and probably offers greater facilities of transit than the transverse routes.

On this point a few words appear to be called for, by the statements of a recent writer, a member of parliament, and formerly an Indian Governor of great distinction, who has denied the existence of lateral communication along and within the Suliman Mountains which form the easternmost part of the Iranian system and extend nearly from the Kabul River to the sea.

So far from lateral communication being wanting in this locality, which is now of much importance on account of its being brought by treaty within the scope of British administration—so far from the lateral communication being deficient and much less altogether absent—it constitutes as in the other mountains which we have discussed, a characteristic and marked feature of them. Indeed the outermost slope or scarp of the eastern Suliman has been delineated like a rising series of parallel gutters, terraces, or troughs, in the beautiful maps of the Derajat prepared by the surveyors under the guidance of Major-General Sir Henry Thuillier, who for so long a time filled the office of Surveyor-General of India, and whose presence here is such an advantage to the section.

In the heart of the mountains two lines of lateral communication can be already traced, even with our present very scanty information. Both are on the east of the waterparting of the Helmund and Indus basins, which is formed by the western range of the Suliman. One skirts the very summits of the range and is formed at its northern limit by the uppermost valleys of the Kurram, west of the Peiwar Kotul. It is watered by a stream which descends from near the Shutargarden Pass to the Kurram, where it meets another branch of the Kurram coming from the Mangal country on the south-western limits of the Kurram basin. From thence there is a communication with the district of Furlmul which was known to the Turki Emperor, geographer, and conqueror of India—the famous Baber. Furlmul lies at the head of the Dawar valley and river, which descends from it straightway to the Indus, but has never yet been wholly traversed by Europeans. Furlmul is occupied by the Karoti tribe of the famous Povindah merchants, unless the Waziri have driven them out.

From Furlmul this lateral line passes on to the Dwa Gummul another haunt of the Karoti people, who, as Povindahs and periodical visitors and traders to India, should have a clear interest in being friendly with us. From the Dwa Gummul we pass on to a southern headwater of the Gummul, and so on to the head of the Zhob valley, which is connected with the Thal-Chotiali route to Peshin.

There is another very important lateral line, a part of which was made known to Lieut. Broadfoot of the Royal Engineers as far back as 1842, by a native name, signifying "the road of the Waziri," a dominant tribe in those parts. This also connects the Kurram valley with the Dawar and Gummul valleys; and it is prolonged from Gummul up to the Chotiali route, by the great Zhob valley, which has at least been distinctly seen from both ends, in a direction nearly meridional. We all know the great road which has been traversed by British troops between Kabul, Ghazni, Kandahar, and Kelat, and eastward of this, on the western side of the western Suliman range, a route has been traversed from Zurmul to lake Abistada, and from the lake to Kelat, British troops have marched over the Toba-highland.

So much by way of proof of abundant lateral communication along the mountains west of the Indus.

One word more relating to the lateral communication through the hills and valleys of the south slope of the great Iranian highland. For it relates to the construction in the near future of a railway to India. From sheer ignorance some have proposed to carry such a line along the coast in a deadly climate with the atmosphere of a permanent hot bath. But the true route is found in one of those elongated lateral valleys which at

a considerable elevation above the sea and in a better climate than that of the lowland on the coast, stretch all along from the Pubb river on the borders of India to Mesopotamia. Among these is the line of the Kej valley and a succession of others leading to Shiraz, from whence there is little doubt that a practical line may be found up to Bagdad.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The Professorship of Experimental Physics has been formally continued by the Senate, and there is now no doubt that if Lord Rayleigh is willing to undertake this onerous office, he will be elected Professor. A memorial requesting him to be a candidate signed by almost every elector in a very short time seems like a command. It shows that there is no fear, and every hope for a beneficial result to education following. Lord Rayleigh's knowledge of the working of the University and the Scientific Commission will give him a most commanding position. It is a clear "call" from the University when such men as Adams, Besant, Cayley, Dewar, Ferrers, Frost, Garnett, J. W. Glaisher, Hughes, Liveing, R. K. Miller, Peile, Pendlebury, Routh, Salvin, Skeat, Stoke, James Stuart, Todhunter, Venn, James Ward, W. Aldis Wright and others unanimously record their view that it would tend greatly to the advance of physical science and to the advantage of the University that Lord Rayleigh should occupy the chair of Experimental Physics at Cambridge.

Messrs. C. W. Moule (Corpus) and S. H. Vines (Christ's) have been appointed members of the Botanic Garden Syndicate till November 20, 1882; Drs. Power and Phear have been appointed on the Museum and Lecture Rooms Syndicate; Mr. Henry Sedgwick and Mr. V. H. Stanton are again on the Local Examinations Syndicate; Messrs. W. D. Niven and G. H. Darwin are appointed on the Observatory Sydicate; Messrs. Bradshaw, Bently and Peile, and Dr. Hart and Mr. Aldis Wright are on the University Press Syndicate; the two latter are special elections in view of the publication of the Revised Translation of the Bible; P. T. Main and F. M. Balfour on the State Medicine Syndicate.

Mr. S. H. Vines is also appointed on the Natural Science Studies; and Dr. Paget has been elected on the Council of the Senate, as a Professor, in Prof. Maxwell's place, for one year, and by only one vote over Prof. Stuart. Dr. Paget has on previous occasions been unwilling to come forward for such an onerous post, and would hardly now have done so, but for the short term of office required, and the importance of the medical and natural science rearrangements at Cambridge demanding his aid if the University showed its confidence in him.

An amended schedule for 2nd M.B. Camb. to come into operation in June, 1880, as far as regards comparative anatomy differs from that at present in force in introducing *excretory* and *reproductive* organs, as being required to be known in addition to the other principal systems: the tapeworms parasitic in man, cockroach, fresh-water mussel, whiting, and rabbit are introduced, while the spider and the cockchafer, oyster, perch, and rat disappear. In the specification as to the vertebrate skeleton, the cod displaces the perch, the dog replaces the rat. These changes all seem to be in the direction of providing larger and more conspicuous and accessible specimens to be studied, or those more necessary for a medical student.

SCIENTIFIC SERIALS

Journal of Botany, September, October, and November.—The last three numbers of this journal are mainly occupied with articles on descriptive and systematic botany, extracts, and reviews, with the exception of two, to which special attention may be called.—In the September number Mr. S. Le M. Moore has a "preliminary notice" on mimicry of seeds and fruits, and the functions of seminal appendages. He points out the number of seeds or fruits that bear a striking resemblance to coleopterous or other insects, by means of which he believes they may often escape from their seminivorous enemies by being passed over as insects, or, being picked up and thrown away by insectivorous birds, may thus become disseminated. He adduces striking instances of this mimicry in Polygalaceæ, Leguminosæ, Umbelliferæ, and especially Euphorbiaceæ, in which the carunculus of the seed closely resembles the head of the insect, and the raphal